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Correlation, path coefficient analysis and construction of indices for yield and yield components selection in forage sorghum [*Sorghum bicolor* (L) Moench]

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ABSTRACT

Correlation and path coefficient analyses are essential tools in selection experiments. They were used to determine direct and indirect relationships between yield and certain plant characters in 40 diverse genotypes of forage sorghum. The estimate of broad sense heritability was highest for green fodder yield plant^{-1} followed by number of leaves plant^{-1}. At genotypic level, leaf length (Rg = 0.612) and leaf width (Rg = 0.750) had positive and highly significant correlation with green fodder yield plant^{-1}, while for rest of the characters they were non significant. Leaf length (Rp = 0.552) and leaf width (Rp = 0.616) had positive and highly significant correlations with green fodder yield plant^{-1} at phenotypic level. The leaf width has highest direct effect on fodder yield followed by leaf length, plant height and number of leaves plant^{-1}. Selection index consisting of plant height at 50 per cent flowering, number of leaves plant^{-1} and leaf length is most reliable to select biometrical characters in plant breeding programmes for the improvement of fodder yield in forage sorghum.

Keywords: Forage sorghum, genotypic correlation, path coefficient analyses, phenotypic correlation, selection index.

Like green revolution, India is contemplating for white revolution, which is possible only with adequate supply of nutritious feeds and fodders. Low fodder production and lesser-feed availability is the major limiting factor for increasing livestock productivity in India. The importance of forage crop in Indian agricultural economy is obvious from the fact that of the cattle wealth. It is estimated that the 60-70 per cent of total cost in livestock production is due to feed and fodder. In India, hardly 5 per cent of the cropped area is utilized to grow fodder. India is deficit in dry fodder by 11 per cent, green fodder by 35 per cent and concentrates feed by 28 per cent. The common grazing lands too have been deteriorating quantitatively and qualitatively (Anon, 2010-11). At present as cattle population survives up to a large extent on crop residues, they are nutritionally poor hence, nutritious forage is very crucial for ensuring optimum level of milk, meat and wool production. Therefore, target could be achieved by developing the varieties or hybrids of forage crop giving high yield per unit area and better quality.

Sorghum is the fifth most important crop in the world. Sorghum ranks first among the cereal fodder crops because of its growing ability in poor soil, faster growth habit, higher yield, palatability and nutritious quality. During the last 30 years the role of sorghum as a major source of fodder has not diminished while its importance as a forage crop has increased (Tonapi *et al.,* 2011). The important sorghum growing states in India are Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, Rajasthan, Tamil Nadu and Gujarat. In Gujarat state, it is mainly grown in North Gujarat, Saurashtra and Kutchh region. The average fodder yield of sorghum in Gujarat is low because major area is covered by local and out-dated varieties. Only 4.4 per cent of the total cropped area of the country is under fodder crops cultivation. As there is little scope of increasing area under cultivation of fodder crops due to urbanization, industrialization and traditional inclination among farmers. Hence, only optional strategy to meet fodder requirement is to exploit crop productivity through better yielding varieties and efficient agronomic management.

In order to make forage sorghum as an enterprising and remunerative crop, there is need to develop varieties or hybrids having early maturity, faster growth and high forage yield coupled with high protein content and low HCN content at flowering stage. Assessment of genetic variability in the base population is the first step in any breeding programme. Durrishahwar *et al.* (2012) showed significant variability for days to 50 per cent flowering, leaf area, plant height and green forage yield. Jain and Patel (2012) found higher genotypic coefficient of variation (GCV) was higher for green fodder yield than dry fodder yield. Kumar (2013) studied the genetic variability, association among the yield components and their direct and indirect effects on the yield in sorghum. Parameters like grain yield and fodder yield coupled with high heritability showed high genetic advance. The yield is a complex character resulting from interplay of

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various yield contributing characters, which have positive or negative association with yield and among themselves. A significant positive genetic correlation between two desired characters makes the plant breeder's job easy to improve both the characters at the same. Contribution of correlation coefficient can be partitioned into direct and indirect effects of different traits towards dependent variable and thence help in evaluating the cause-effect affiliation along with effective selection .The knowledge of existing genetic variability and estimation of heritability for yield and its correlation in a population is very important in determining the influence of environment for the expression of the characters, and the extent to which improvement is possible after selection. The magnitude of correlations between various characters with yield would be helpful in the selection of characters for the improvement of yield. Keeping in view the importance of sorghums as fodder crop, the present study was therefore initiated to know the variability, correlation and selection of traits to improve yield of high fodder yielding varieties for Gujarat.

MATERIAL AND METHODS

The present investigation was conducted at Main Forage Research Station, A.A.U., Anand, during *kharif* season of the year 2013. Anand is situated at $22^0 35'$ North Latitude and $72^0 55'$ East longitude and 45.11 m above the mean sea level. The soil of experimental field is sandy loam, which is locally known as "*Goradu Soil*." It is alluvial in origin, deep, well drained and has fairly good moisture holding capacity. It is poor in organic matter, medium in available phosphorous and rich in available potash. It responds well to irrigation and nitrogen application. The experimental material for present investigation comprised of 40 diverse genotypes of forage purpose sorghum obtained from the germplasm maintained at Main Forage Research Station, A.A.U., Anand. The details of these genotypes are listed in table1.

The experiment was conducted in RBD with three replications and 30 x 10 cm spacing. The observations on green fodder yield and its component character were recorded from five randomly selected competitive plants for each treatment in each replication and the average values per plant were computed. The data available for the present study were received for following biometrical characters. The details of characters are explained in table 2.

The data were statistically analyzed as per standard statistical process. Variability parameters were calculated according to the standard statistical procedures (Burton, 1952; Johnson *et al*., 1955; Al-Jibouri *et al.,* 1958; Dewey and Lu, 1959). The genotypic correlation is chiefly caused by pleiotrophy and linkage action of gene and was estimated as suggested by Hazel *et al*. (1943). The genotypic and phenotypic correlation coefficients were worked out for all possible pairs and were tested against standardized tabulated significant values as per the procedure suggested by Fisher and Yates (1943).

The cause and effect, interrelationship between two variables cannot be estimated from correlation coefficient analysis. The genotypic correlations are free from environmental influence and hence, it's the path analysis suggested by Wright (1921) was followed in order to partition genotypic correlation of different variables with fodder yield into direct and indirect effects of these variables on yield. The path coefficients were obtained by solving simultaneous equations which represent the basic relationship between correlation and path coefficient.

The magnitude of correlations between various characters with yield would be helpful in the selection of characters for the improvement of yield. Selection index was first proposed by Smith (1936) based on the "discriminant function" of Fisher (1936). The aim of most breeding programmes are simultaneous improvement of several characters. It has been recognized that most rapid improvement in the economic value is expected from selection applied simultaneously to all the characters which determine the economic value of a plant, appropriate weights are assigned to each character according to their relative economic importance. However there is no standard procedure to assign weight, Hazel (1943) also developed a method of index selection based on the path coefficients. The selection indices will be constructed taking all possible combinations of characters, assigning path coefficients (Direct effect) of the characters as weight.

RESULTS AND DISCUSSION

The variations among genotypes for different characters were found highly significant. The results of mean performance are given in table 3. Maximum plant height was recorded for genotype DSIS-8731 (276.80cm) and it was *at par* with the genotypes PB-19, PB-79 and PB-215. Plant height ranged from 157.23 cm (AFS-23) to 276.80 cm with an average of 220.85 cm. SSG 59-3 had highest no. of tillers (3.40) and it was *at par* with the genotypes AFS-26, AFS-28 and DSIS-5535 with general mean of 2.31 tillers per plant. The differences among the genotypes were highly significant for number of leaves per plant. The maximum numbers of leaves per plant were recorded for AFS-26 (22.8) and it was significantly superior over all genotypes. The average numbers of leaves were 12.05

plant^{-1}. The genotype GFS-3 (93.83 cm) had highest leaf length and it was *at par* with genotype Chitra. The average leaf length was observed to be 73.15 cm. Genotype Chitra had the highest leaf width (6.53 cm) followed by genotypes Amruta (6.47 cm) and PB-181(6.47 cm). Out of 40 genotypes, 17 had leaf width higher than the general mean of 4.9 cm. The genotypic difference in respect of green fodder yield plant^{-1} was highly significant. Significantly highest green fodder yield plant^{-1} was recorded by Chitra (306.67 g) with general mean of 125.8 g plant^{-1}. The highest genotypic coefficient of variation (%) were observed for green fodder yield (43.08%) followed by number of leaves plant^{-1}, number of tillers plant^{-1}, leaf width, plant height and the lowest in leaf length (11.59%). The same trend was observed for phenotypic coefficient of variation. In general the P. C.V. percentage was higher than G.C.V. per centage which indicated small influence of environment on the characters under study. The broad sense heritability was highest for green fodder yield plant^{-1} followed by number of leaves per plant. The lowest heritability was 68.0 per cent in leaf width.

Table 1: List of genotypes studied and their resources

No	Genotypes	Pedigree / Source
1	AFS-14	Local selection from kutchh district (MFRS)
2	AFS-15	Local selection from kutchh district (MFRS)
3	AFS-26	Piper -18 x SSG 59-3 (MFRS)
4	AFS-28	Piper -83 x SSG 59-3 (MFRS)
5	AFS-30	Piper -19 x SSG 59-3 (MFRS)
6	PB-19	PBRS, GAU, Anand
7	PB-23	PBRS, GAU, Anand
8	PB-78	PBRS, GAU, Anand
9	PB-79	PBRS, GAU, Anand
10	PB-181	PBRS, GAU, Anand
11	PB-215	PBRS, GAU, Anand
12	PB-266	PBRS, GAU, Anand
13	IS 685-14	ICRISAT, Hyderabad
14	IS-686	ICRISAT, Hyderabad
15	IS-3192	ICRISAT, Hyderabad
16	IS-3214	ICRISAT, Hyderabad
17	IS-3347	ICRISAT, Hyderabad
18	IS-3353-1	ICRISAT, Hyderabad
19	IS-3367	ICRISAT, Hyderabad
20	SS-96-785	ICRISAT, Hyderabad
21	IS KMR-8	ICRISAT, Hyderabad
22	Piper-56	PBRS,GAU, Anand
23	Piper-83	PBRS,GAU, Anand
24	ICRISAT-700	ICRISAT, Hyderabad
25	ASFS-5	Local Selection, MFRS, Anand
26	DSIS-243	PBRS, GAU, Anand
27	DSIS-1005	PBRS, GAU, Anand
28	DSIS-5535	PBRS, GAU, Anand
29	DSIS- 8731	PBRS, GAU, Anand
30	C-10-2	Selection from Chhasathio Jowar of Saurashtra
31	S-1049	Local selection from Sundhia Jowar
32	UP-Chari	IS-4776, Local collection from Majevadi, Junaghadh
33	MP-Chari	JNKV, Madhya Pradesh
34	SSG-59-3	Derivate of the cross Non Sweet Sudan grass x Sweet Jowar IS-263
35	COFS-29	Derivate of the cross TNS 30 x S. Dudanenie
36	GFS-3	Selection from IS-5026
37	GFS-5	Released from surat centre
38	Gundri	Local variety of saurastra
39	Chitra	AICRP forage Project, Rahuri
40	Amruta	AICRP forage Project, Rahuri

Table 2: Detail of characters for the investigation

Sl.No.		Character	Description
1	X_1:	Plant height at 50 % flowering	Measured from ground level to the tip of the panicle in cm. and the mean value was computed.
2	X_2:	Number of tillers per plant	Recorded by counting the sprouted tillers from base including the tagged plant at the time of harvesting and the mean value was computed.
3	X_3:	Number of leaves per plant	Recorded by counting the leaves from individual sample plant at the time of harvesting and the mean value was computed.
4	X_4:	Leaf length	Measured in cm. from leaf base to tip of leaf. The fourth leaf from the top was selected for measurement of leaf length and the mean value was computed.
5	X_5:	Leaf width	Measured in cm. from the middle region of the leaf
6	X_6:	Green fodder yield per plant	Recorded in grams by weighing the five plants together immediately after harvest at 50 per cent flowering stage and average was worked out.

The correlation coefficients between green fodder yield per plant and its component traits among themselves were estimated at genotypic and phenotypic levels. The results of genotypic and phenotypic correlation coefficients between yield and its components are given in table 4. Genotypic correlation coefficient revealed that Leaf length (Rg = 0.612**) and leaf width (Rg = 0.750**) had positive and highly significant correlation with green fodder yield per plant at genotypic level, while for rest of the characters they were non significant. Number of tillers per plant had significant and negative correlation with plant height and positive significant with number of leaves per plant. Plant height had positive and significant correlation with leaf width (Rg = 0.326*) at genotypic level. Number of leaves per plant had significant and positive correlation with leaf length (Rg = 0.403*) at genotypic level. Leaf length and leaf width had significant and positive correlation (Rg = 0.436*). Also the phenotypic correlation revealed that Leaf length (Rp = 0.552**) and leaf width (Rp = 0.616**) had positive and highly significant correlations with green fodder yield per plant at phenotypic level. Number of tillers per plant showed significant and negative correlation with plant height and significant and positive correlation with number of leaves per plant (Rp=0.332*). Plant height had significant positive correlation with leaf width (Rp = 0.248*) and it was negatively correlated with number of leaves per plant. Number of leaves per plant had highly significant and positive correlation with leaf length (Rp = 0.398**) at phenotypic level. Leaf length had significant and positive correlation with leaf width (Rp = 0.388*) and green fodder yield per plant (Rp = 0.552*) at phenotypic level.

Significant and positive genotypic / phenotypic correlations between fodder yield and leaf width as observed in present study were also reported by Sood and Ahluwalia (1989), Yadav *et al.* (2003) and Jain and Patel (2012). The results pertaining to positive significant correlations between fodder yield per plant and leaf length observed in present study are also in accordance with those reported by Yadav *et al.* (2003), Agrawal (2004), Singh (2013) and Jain and Patel (2012).The results for other characters are in partial agreement with other workers. In general genotypic correlations were higher in magnitude as compared to phenotypic correlation coefficients. Similar findings were reported by Singh (2013). They showed same trend of association at both the levels.

Green fodder yield per plant is the result of direct and indirect effects of several yield contributing characters. To know the contribution of various characters towards green fodder yield, the genotypic correlation of different characters with green fodder yield per plant were partitioned into their direct and indirect effects. This will provide more valuable information for the selection of important characters. Direct and indirect effects of five casual variables on green fodder yield per plant are given in table 5.

Table 3: Mean performance of genotypes for yield and yield contributing characters in forage sorghum.

Sl. No.	Genotypes	Plant height at 50% flowering (cm)	No. of tillers plant^{-1}	No. of leaves plant^{-1}	Leaf length (cm)	Leaf width (cm)	Green fodder yield plant^{-1} (g)
1.	AFS-14	217.00	2.30	18.8	78.33	4.7	124.60
2.	AFS-15	189.73	2.61	14.2	75.23	5.03	99.00
3.	AFS-26	190.70	3.12	22.8	69.20	3.60	97.67
4.	AFS-28	158.30	3.12	16.47	82.93	4.17	98.00
5.	AFS-30	157.23	2.63	14.13	76.33	4.67	93.33
6.	PB-19	263.87	1.30	14.00	82.67	6.30	200.0
7.	PB-23	220.37	2.70	13.00	79.33	6.13	192.61
8.	PB-78	230.40	2.43	7.67	66.67	3.53	59.67
9.	PB-79	260.27	2.37	10.00	66.67	5.17	144.0
10.	PB-181	244.87	2.50	10.00	80.00	6.47	202.70
11.	PB-215	258.17	1.33	9.33	76.67	4.67	128.70
12.	PB-266	253.63	2.53	10.33	76.00	3.67	102.00
13.	IS 685-14	233.20	2.40	8.33	66.67	4.63	51.00
14.	IS 686	198.47	2.73	7.00	58.33	2.77	50.00
15.	IS-3192	214.67	1.40	9.00	56.00	4.80	45.17
16.	IS-3214	212.03	2.47	8.67	56.67	4.73	46.67
17.	IS-3347	217.80	1.93	10.67	61.00	5.63	171.30
18.	IS-3353-1	210.50	2.43	6.67	67.00	4.03	65.00
19.	IS-3367	255.33	1.97	9.00	63.00	4.37	80.00
20.	SS-96-785	245.27	2.40	10.00	69.00	5.67	141.00
21.	IS KMR-8	211.97	2.30	11.00	74.33	6.13	137.00
22.	PIPER-56	250.47	1.70	7.67	63.33	4.20	61.40
23.	PIPER-83	253.37	1.47	9.00	70.00	4.37	115.0
24.	ICRISAT-700	239.50	1.80	9.33	78.33	5.50	130.10
25.	ASFS-5	255.47	1.80	9.67	70.67	5.03	175.00
26.	DSIS-243	250.69	2.07	11.00	77.67	6.27	173.70
27.	DSIS-1005	245.40	2.70	8.67	71.33	4.57	117.30
28.	DSIS-5535	235.32	3.30	10.67	73.67	4.20	116.20
29.	DSIS-8731	276.80	2.10	11.67	64.33	5.97	190.00
30.	C-10-2	184.67	2.00	15.07	64.30	3.50	119.00
31.	S-1049	210.50	2.10	16.73	69.67	3.50	91.00
32.	UP-CHARI	177.60	2.00	14.47	77.67	5.03	107.70
33.	MP-CHARI	199.80	2.80	14.87	73.87	4.53	147.00
34.	SSG 59-3	185.92	3.40	16.87	76.80	4.10	88.00
35.	COFS-29	190.37	2.83	15.67	83.53	5.67	113.30
36.	GFS-3	194.43	3.00	12.00	93.83	5.53	201.30
37.	GFS-5	213.20	2.00	17.80	77.60	4.20	178.00
38.	GUNDRI	181.70	2.37	15.47	87.20	4.70	132.00
39.	CHITRA	222.52	1.20	9.00	88.17	6.53	306.70
40.	AMRUTA	213.61	3.00	15.53	81.60	6.47	141.70
	Mean	**220.85**	**2.31**	**12.05**	**73.15**	**4.9**	**125.80**
	S Em(±)	**6.90**	**0.13**	**0.50**	**2.05**	**0.35**	**2.14**
	LSD(0.05)	**19.53**	**0.37**	**1.41**	**5.82**	**1**	**6.04**
	C.V.(%)	**5.55**	**10.19**	**7.35**	**5.00**	**12.83**	**5.21**
	G.C.V.	**13.11**	**23.45**	**30.60**	**11.59**	**18.72**	**43.08**
	P.C.V.	**14.23**	**25.57**	**31.47**	**12.62**	**22.69**	**43.39**
	Heritabiliy (%)	**84.80**	**84.10**	**94.50**	**84.40**	**68.00**	**98.60**

Table 4: Genotypic and phenotypic correlation coefficients among different characters in sorghum

Characters		PLH	NTP	NLP	LL	LW	GFYPP
PLH	Rg	1.000	-0.495**	-0.561**	-0.242	0.326*	0.253
	Rp	1.000	-0.432**	-0.494**	-0.203	0.248*	0.220
NTP	Rg		1.000	0.355 *	0.192	-0.232	-0.247
	Rp		1.000	0.332**	0.147	-0.150	-0.224
NLP	Rg			1.000	0.403*	-0.076	0.117
	Rp			1.000	0.398**	-0.052	0.106
LL	Rg				1.000	0.436**	0.612**
	Rp				1.000	0.388**	0.552**
LW	Rg					1.000	0.750**
	Rp					1.000	0.616**
GFYPP	Rg						1.000
	Rp						1.000

Note: Rg = genotypic and Rp= phenotypic correlations, ** Significant at P = 0.05 and 0.01 levels, respectively. PLH: Plant height at 50% flowering, NTP: Number of tillers plant^{-1}, NLP: Number of leaves plant^{-1} LL: Leaf length (cm), LW: Leaf width (cm), GFYPP: Green fodder yield plant^{-1}.*

Table 5: Genotypic path coefficients analysis (direct and indirect effects) of causal variables on green fodder yield per plant in sorghum

Sl. No.	Characters	PLH	NTP	NLP	LL	LW	Geno. Corr. with GFYPP
1	PLH	**0.207**	0.086	-0.088	-0.104	0.153	0.253
2	NTP	-0.102	**-0.174**	0.056	0.082	-0.108	-0.247
3	NLP	-0.116	-0.062	**0.158**	0.172	-0.036	0.117
4	LL	-0.050	-0.033	0.064	**0.427**	0.204	0.612**
5	LW	0.067	0.040	-0.012	0.187	**0.468**	0.750**

*Note: *, ** Significant at P = 0.05 and 0.01 levels, respectively.*
PLH: Plant height at 50% flowering, NTP: Number of tillers plant^{-1},
NLP: Number of leaves plant^{-1}, LL: Leaf length(cm), LW: Leaf width (cm),
GFYPP: Green fodder yield plant^{-1} (g).

Plant height had positive and non significant (Rg = 0.253) genotypic correlation with green fodder yield plant^{-1} however, its direct effect was positive (0.207) on green fodder yield plant^{-1}. It had positive indirect effect on green fodder yield plant^{-1} *via* leaf width and number of tillers plant^{-1}. While, indirect effects via other traits were negative with lower magnitude. Negative and non significant genotypic correlation (Rg = -0.247) was observed between number of tillers per plant and green fodder yield plant^{-1} and its direct effect was also negative (-0.174) on green fodder yield plant^{-1}. While it's indirect effect through plant height and leaf width were negative whereas, indirect effect through leaf length and number of tillers plant^{-1} were positive. Number of leaves plant^{-1} exhibited positive and non-significant genotypic correlation (Rg = 0.117) with green fodder yield plant^{-1} and it had positive direct effect (0.158) on green fodder yield plant^{-1}. This trait showed positive indirect effect through leaf length while, its indirect effects via rest of the characters were negative. Leaf length showed positive and highly significant genotypic correlation (Rg = 0.612**) with green fodder yield plant^{-1}. Leaf length had positive direct effect (0.427) on green fodder yield plant^{-1}. Its indirect effects through plant height and number of tillers plant^{-1} were negative. While, indirect effects via rest of traits were positive. Leaf width exhibited positive and highly significant genotypic correlation (Rg =0.750**) with green fodder yield plant^{-1} with positive direct effect of this character (0.468).

Looking to the direct effect of genotypic path coefficients, leaf width was having the high direct effect followed by leaf length, plant height and number of

Table 6: Selection indices, expected genetic gain and relative efficiency (%) based on path coefficient as weight taking all possible combinations of characters

Sl. No.	Equations	Genetic Gain	RE(%)
	Single character		
I_1	$I = 0.1755 X_1$	11.36	10.25
I_2	$I = -0.2093 X_2$	0.23	0.20
I_3	$I = 0.1494 X_3$	1.17	1.05
I_4	$I = 0.3602 X_4$	6.85	6.18
I_5	$I = 0.3196 X_5$	0.73	0.66
I_6	$I = 0.9855 X_6$	110.86	100.00
	All possible combinations of two characters		
I_{12}	$I = 0.1673 X_1 -1.1686 X_2$	11.51	10.38
I_{13}	$I = 0.1634 X_1 -0.0423 X_3$	10.75	9.70
I_{14}	$I = 0.1696 X_1 + 0.3329 X_4$	11.51	10.38
I_{15}	$I = 0.1748 X_1 + 0.5460 X_5$	11.69	10.55
I_{16}	$I = 0.1993 X_1 + 0.9878 X_6$	114.65	103.42
I_{23}	$I = -0.2127 X_2 + 0.1518 X_3$	1.12	1.01
I_{24}	$I = 0.1157 X_2 + 0.3573 X_4$	6.81	6.15
I_{25}	$I = -0.2920 X_2 + 0.3128 X_5$	0.83	0.75
I_{26}	$I = -10.3249 X_2 + 0.9669 X_6$	111.45	100.53
I_{34}	$I = 0.1810 X_3 + 0.3540 X_4$	7.41	6.68
I_{35}	$I = 0.1458 X_3 + 0.3129 X_5$	1.31	1.19
I_{36}	$I = 0.3639 X_3 + 0.3192 X_6$	111.00	100.13
I_{45}	$I = 0.4472 X_4 + 0.9840 X_5$	7.23	6.53
I_{46}	$I = 0.7809 X_4 + 0.9816 X_6$	115.60	104.28
I_{56}	$I = 0.3201 X_5 + 0.9620 X_6$	111.52	100.60
	All possible combinations of three characters		
I_{123}	$I = 0.1580 X_1 -0.9726 X_2 -0.0223 X_3$	10.88	9.81
I_{124}	$I = 0.1640 X_1 -0.8781 X_2 + 0.3355 X_4$	11.61	10.47
I_{125}	$I = 0.1666 X_1 -1.1974 X_2 + 0.5233 X_5$	11.84	10.68
I_{126}	$I = 0.0982 X_1 -13.0987 X_2 + 0.9769 X_6$	115.38	104.07
I_{134}	$I = 0.2211 X_1 -0.1727 X_3 + 1.5308 X_4$	29.54	26.64
I_{135}	$I = 0.1619 X_1 -0.0474 X_3 + 0.5949 X_5$	11.09	10.00
I_{136}	$I = 0.2651 X_1 + 1.1600 X_3 + 0.9717 X_6$	114.97	103.71
I_{145}	$I = 0.1657 X_1 + 0.3126 X_4 + 0.7748 X_5$	12.06	10.88
I_{146}	$I = 0.1988 X_1 + 0.4258 X_4 + 0.9884 X_6$	119.06	107.40
I_{156}	$I = 0.0130 X_1 + 45.2203 X_5 + 0.4497 X_6$	140.66	126.88
I_{234}	$I = 0.0777 X_2 + 0.1690 X_3 + 0.3534 X_4$	7.36	6.64
I_{235}	$I = -0.3003 X_2 + 0.1526 X_3 + 0.3061 X_5$	1.31	1.18
I_{236}	$I = -9.1071 X_2 + 0.4954 X_3 + 1.0747 X_6$	117.42	105.92
I_{245}	$I = 0.0375 X_2 + 0.3603 X_4 + 0.3502 X_5$	7.21	6.50
I_{246}	$I = -11.5389 X_2 + 0.6992 X_4 + 0.9397 X_6$	116.23	104.84
I_{256}	$I = -10.3642 X_2 + 0.3739 X_5 + 0.9680 X_6$	112.12	101.13
I_{345}	$I = 0.1738 X_3 + 0.3581 X_4 + 0.3358 X_5$	7.75	6.99
I_{346}	$I = 0.1175 X_3 + 0.4517 X_4 + 0.9839 X_6$	115.77	104.43
I_{356}	$I = 0.1838 X_3 + 0.7895 X_5 + 0.9813 X_6$	111.67	100.73
I_{456}	$I = 0.4430 X_4 + 0.4194 X_5 + 0.9851 X_6$	116.26	104.87

Table 6 continued

Table 6 continued

All possible combinations of four characters			
I_{1234}	$I=0.1561 X_1 - 0.7233 X_2 - 0.0115 X_3 + 0.3539 X_4$	11.26	10.16
I_{1235}	$I=0.1567 X_1 - 0.9885 X_2 - 0.0266 X_3 + 0.5720 X_5$	11.22	10.12
I_{1236}	$I = 0.1173 X_1 -13.6570 X_2 + 0.5167 X_3 + 0.9707 X_6$	115.47	104.16
I_{1245}	$I = 0.1607 X_1 -0.8469 X_2 + 0.3168 X_4 + 0.7446 X_5$	12.15	10.96
I_{1246}	$I = 0.1109 X_1 -13.3649 X_2 + 0.5787 X_4 + 0.9611 X_6$	119.76	108.03
I_{1256}	$I = 0.0967 X_1 -13.1354 X_2 + 0.7647 X_5 + 0.9734 X_6$	116.05	104.68
I_{1345}	$I = 0.0015 X_1 -0.0219 X_3 + 0.1485 X_4 + 2.4248 X_5$	7.21	6.50
I_{1346}	$I = 0.0012 X_1 -0.0253 X_3 + 0.1445 X_4 + 1.041 X_6$	118.65	107.03
I_{1356}	$I = 0.0016 X_1 -0.0290 X_3 + 1.6368 X_5 + 0.9996 X_6$	114.81	103.56
I_{1456}	$I = 0.1986 X_1 + 0.4214 X_4 + 0.4117 X_5 + 0.9895 X_6$	119.73	108.00
I_{2345}	$I = 0.0073 X_2 + 0.1668 X_3 + 0.3564 X_4 + 0.3570 X_5$	7.72	6.96
I_{2346}	$I = -12.6778 X_2 + 0.6679 X_3 + 0.6195 X_4 + 0.9411 X_6$	116.44	105.04
I_{2456}	$I = -59.8016 X_2 -0.8105 X_4 + 228.5589 X_5 + 3.9778 X_6$	7.71	6.95
I_{3456}	$I = 0.1101 X_3 + 0.4493 X_4 + 0.3757 X_5 + 0.9854 X_6$	116.43	105.02
I_{2356}	$I = -12.4304 X_2 + 0.8624 X_3 + 0.7496 X_5 + 0.9541 X_6$	112.37	101.36
All possible combinations of five characters			
I_{12345}	$I = 0.1535 X_1 -0.7082 X_2 + -0.0029 X_3 + 0.3360 X_4 + 0.7109 X_5$	11.81	10.66
I_{12346}	$I=0.1789 X_1 -15.1106 X_2 +1.5052 X_3 + 0.42402 X_4 + 0.9533 X_6$	120.09	108.32
I_{12356}	$I = 0.1159 X_1 -13.7052 X_2 + 0.5264 X_3 + 0.8793 X_5 + 0.9655 X_6$	116.14	104.76
I_{12456}	$I = 0.11181 X_1 -13.3683 X_2 + 0.5775 X_4 + 0.2327 X_5 + 0.9640 X_6$	120.42	108.63
I_{13456}	$I = 0.1923 X_1 + 0.0454 X_3 + 0.4314 X_4 + 0.3570 X_5 + 0.9909 X_6$	119.82	108.08
I_{23456}	$I = -12.7277 X_2 + 0.6608 X_3 + 0.6204 X_4 + 0.1204 X_5 + 0.9454 X_6$	117.10	105.63

leaves plant^{-1}. Positive and high direct effect observed in present study for leaf length and leaf width were also reported by Phul *et al.* (1972), Paroda *et al.* (1975), Gopalan and Balasubramanian (1978), Grewal *et al.* (1983), Prakesh *et al.* (2010) and Jain and Patel (2012). Thus, the present findings are in agreement with these reports while for rest of the characters the results are in partial agreement.

Selection indices were constructed taking all six biometrical characters. The selection indices were constructed taking all possible combinations of characters. Total 63 selection indices were constructed using, direct effects of biometrical characters based on genotypic correlations. After constructing 63 selection indices each for different combination of characters are given in table 6. Their expected genetic gain was calculated for each index. The expected genetic gain obtained from selection index of green fodder yield was considered to work out percent relative efficiency of different indices.

The genetic gain for green fodder yield (110.86) was considered as 100. Relative to this, the efficiency was worked out for selection of single character, the respective relative efficiency are provided in the table. All possible combinations of two characters of six biometrical characters were used to construct selection indices. Total 15 indices were constructed and the indices with their percent relative efficiency are given in table 6. I_{46} and I_{16} show high relative efficiency of 104.28 and 103.42 respectively. Similarly for all possible combination of three, four and five the relative efficiency of $I_{146,}$ I_{1246} and I_{12456} are (126.88, 108.03 and 108.63) highest among all combinations of characters.

The conclusion that can be reached from the present investigation was at genotypic level for leaf length (Rg = 0.612**) and leaf width (Rg = 0.750**) had positive and highly significant with green fodder yield plant^{-1}, while for rest of the characters they were non significant. Leaf length (Rp = 0.552**) and leaf width (Rp = 0.616**) had positive and highly significant correlations with green fodder yield plant at phenotypic level. The leaf width has highest direct effect on fodder yield followed by leaf length, plant height and number of leaves plant^{-1}. From the preceding results it can be also concluded that selection index I_{134} (Plant height at 50% flowering, number of leaves plant^{-1} and leaf length) is most reliable to select biometrical characters in plant breeding programmes for the improvement of fodder yield in forage sorghum.

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